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Reprinted from TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY
Vol. 90, No. 1, January, 1961
pp. 32–41

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ABSTRACT

Pigment analyses have been made of a lagoon emptying into the Gulf of Mexico. This water showed a typical cycle of early spring flowering, later spring minimum, summer oscillations, and a secondary early fall maximum. The cycle resembled those of more northern waters, but the blooms in East Lagoon occurred earlier in the year. The bloom periods were related to various physical factors—solar radiation, temperature, and rainfall—with a direct relationship between incident radiation and chlorophyll *a* production indicated for the fall of 1957. The chlorophyll production of the lagoon compared favorably with other waters in these latitudes, yielding a mean of 17.6 mg chlorophyll a/m^3 during the sampling period from October 1957 to May 1959. An analysis of the precision of the method indicated a standard error of 0.565 ± 0.085 mg/m^3 for chlorophyll *a* and 1.35 ± 0.165 MSPU/m^3 for chlorophyll *c*. The large value for the latter pigment is attributed to the method of calculation.

INTRODUCTION

The analysis and measurement of plankton pigments is now a standard practice in the fields of limnology and oceanography. Dating from the time of Willstatter and Stoll who related plant pigments (more particularly chlorophyll *a*) to the amount of photosynthesis, various authors have used this measurement either to indicate standing crop or as an index of the potential production of an area (Ryther, 1956). In the present report pigments have been used as an index of standing crop in a sub-tropical estuary in conjunction with a study of the effects of a copper ore dike upon the ecology of East Lagoon, Galveston, Texas. Data were gathered for 11 months prior to the addition of copper ore in the lagoon and for the following 9 months. Since no marked effects due to the ore itself were noted (Marvin, 1959), only the effects of the yearly climatic cycle upon the standing crop and potential production will be discussed.

METHODS

The lagoon is a narrow body of water 1.1 miles long and 230 feet wide at the narrowest point with a volume of approximately 75 million gallons. Figure 1 shows the location of the lagoon and the sampling stations with reference to the Houston Ship Channel. The Gulf of Mexico is approximately one-fourth mile south of the lagoon at its closest point. Stations were numbered from the head of the lagoon, with station 1 being the deepest (4.4 meters) and receiving the greatest amount of drainage from the surrounding marsh. Stations 7 and 8 at the mouth of the lagoon were 2.5 meters deep and were subject to greater tidal action than the others. The ore dike, when established, was placed between stations 3 and 4 which were intermediate in depth. All stations were along the deeper axis of the lagoon.

The frequency of sampling varied during the experimental period. With few exceptions, samples were taken at least twice each week from the inception of the work in October 1957 until the end of October 1958, after which weekly samples were taken. Eight stations were sampled until December 1958 when the stations sampled were reduced to stations 1, 4, and 7. Samples were taken at the same time of day to minimize differences due to light intensity.

Fifty gallons of water were pumped into a polyethylene drum at each station while the intake hose was moved up and down from the surface to within a foot of the bottom. The temperature of this composite sample was taken, and 2-liter samples were then removed for analysis. Salinities were taken with a hydrometer and the samples treated with $MgCO_3$ immediately upon return to the laboratory. After overnight storage in a refrigerator, the samples were stirred and 1 liter filtered through a Millipore apparatus (Creitz and Richards, 1955) and the residue extracted with 90 percent reagent-grade acetone (Richards with Thompson, 1952) for the determination of plankton pigments. The extraction was

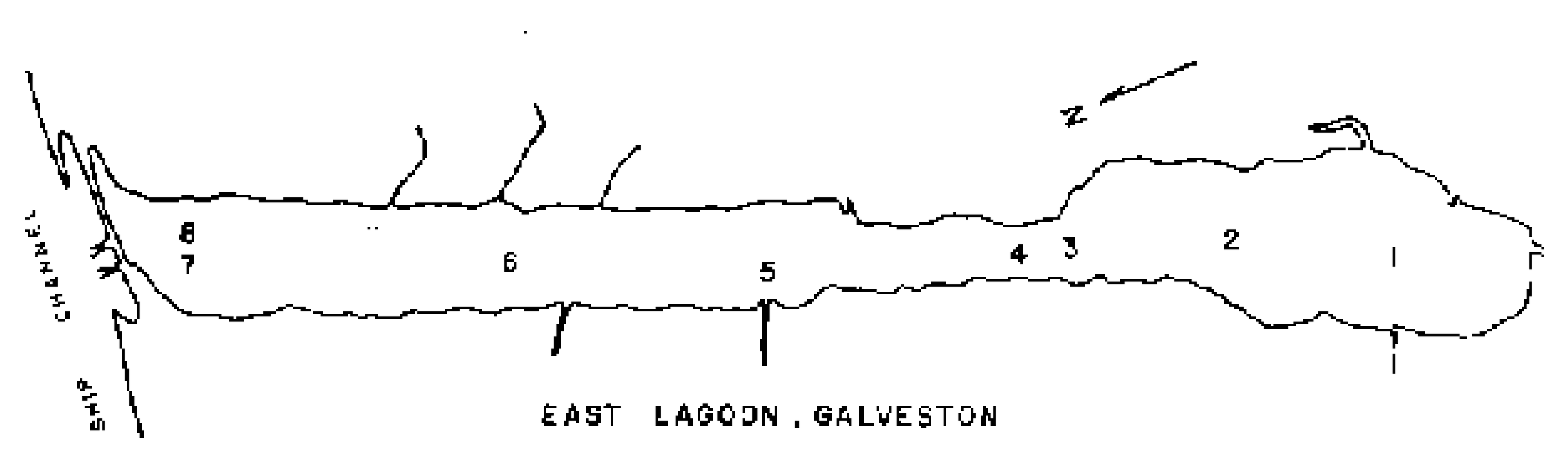

FIGURE 1.—East Lagoon, Galveston, Texas, showing stations sampled.

TABLE 1.—*Precision of the method*

Pigment	Number of samples	Mean pair difference (MSPU or mg/l of extract)	Standard error of mean
Chlorophyll *a*	141	0.113	±0.017
Chlorophyll *b*	141	0.060	±0.008
Chlorophyll *c*	141	0.270	±0.033
Astacin-type carotenoids	141	0.030	±0.003
Non-astacin carotenoids	141	0.072	±0.006

allowed to proceed in the dark for 18 to 24 hours at room temperature after which the optical densities of the extracts were read in a Beckman DU spectrophotometer at 665, 645, 630, 510, and 480 mμ and the amount of pigment calculated.

PRECISION OF METHOD

For the first 2 months of the project each 2-liter sample was divided in half and each liter filtered, extracted, and read as a separate determination. Table 1 shows the precision based upon 141 of these duplicate samples. The chlorophyll *c* values showed greater pair differences than those of any other pigment. This may in part be ascribed to the method of calculation, for instrumental readings are multiplied by a factor of 100. Thus a slight instrumental or operator error may have resulted in larger variations in the final calculated value for chlorophyll *c*. Greater pair differences in chlorophyll *a* tend to occur when larger quantities of pigment are present. This may be due in part to errors in extraction, as cited by Odum, McConnell, and Abbott (1958), when plankton blooms are occurring. Extraction errors may result from the presence of heavy walled organisms which are difficult to break up with the usual trituration and extraction so that duplicate samples may not be extracted equally well. There may also be a constant percentage error inherent in the procedure, resulting in larger differences at higher pigment concentrations.

A second type of precision study was also carried out. Fifty gallons of water were pumped from a single station, and from this amount eight 2-liter samples were returned to the laboratory for analysis. Duplicates of each sample were analyzed as described in the preceding section. These analyses indicated that the values reported for the duplicates were more precise than the values for replicates from one sample. For this reason, only single samples were taken during the latter phase of the project.

TABLE 2.—*Destruction of pigments by heat and light*

Pigment	Original concentration (mean)	Final concentration (mean)	Percentage of original
Chlorophyll *a*	4.55 mg/l	2.09 mg/l	45.0
Chlorophyll *b*	0.18 mg/l	0.12 mg/l	63.7
Chlorophyll *c*	2.03 MSPU/l	1.36 MSPU/l	66.9
Astacin carotenoids	0.26 MSPU/l	0.31 MSPU/l	123.1
Non-astacin carotenoids	1.33 MSPU/l	0.65 MSPU/l	46.0

A further check was made on the stability of the pigments in samples untreated with $MgCO_3$ and not refrigerated. The $MgCO_3$ served to prevent the breakdown of the chlorophylls to the corresponding pheophytins whose absorption peaks do not correspond to the peaks of the original compounds. Refrigeration inhibited bacterial action, as well as the action of light and heat in the destruction of the pigments. A single set of eight samples (duplicates of a set previously treated and analyzed) was held without the addition of $MgCO_3$ at room temperature for 3 days following collection. At the end of this time they were treated, extracted, and read as usual. The change in each type of pigment under these conditions emphasized the need for prompt treatment and analysis (Table 2). It further indicated the necessity for analysts, in reporting on work of this kind, to state the type of treatment given to the sample and the length of time it was held prior to analysis.

Table 2 shows that about 55 percent of both the chlorophyll *a* and the non-astacin carotenoids were destroyed by room light and temperature. Chlorophyll *b* and *c*, on the other hand, have suffered only about 35 percent destruction, and the astacin-type carotenoids have apparently increased. Some of these differences are undoubtedly due to the spectral shifts, mentioned above, when a pigment is converted to a degradation product. However, it is noteworthy that the chlorophyll *c* values remained relatively high so that the chlorophyll *a* to chlorophyll *c* ratio, which has been used by some authors to characterize inshore and offshore waters (Currie, 1958), decreased by about one-third.

RESULTS OF SURVEY

As stated earlier, the regular sampling of the lagoon for plankton pigments began in October 1957 and continued until the end of May 1959. Figures 2 through 7 show the cycle in the lagoon of chlorophyll *a* (mg/m^3), chlorophyll *c* ($MSPU/m^3$), non-astacin or plant-type carotenoids ($MSPU/m^3$), solar ra-

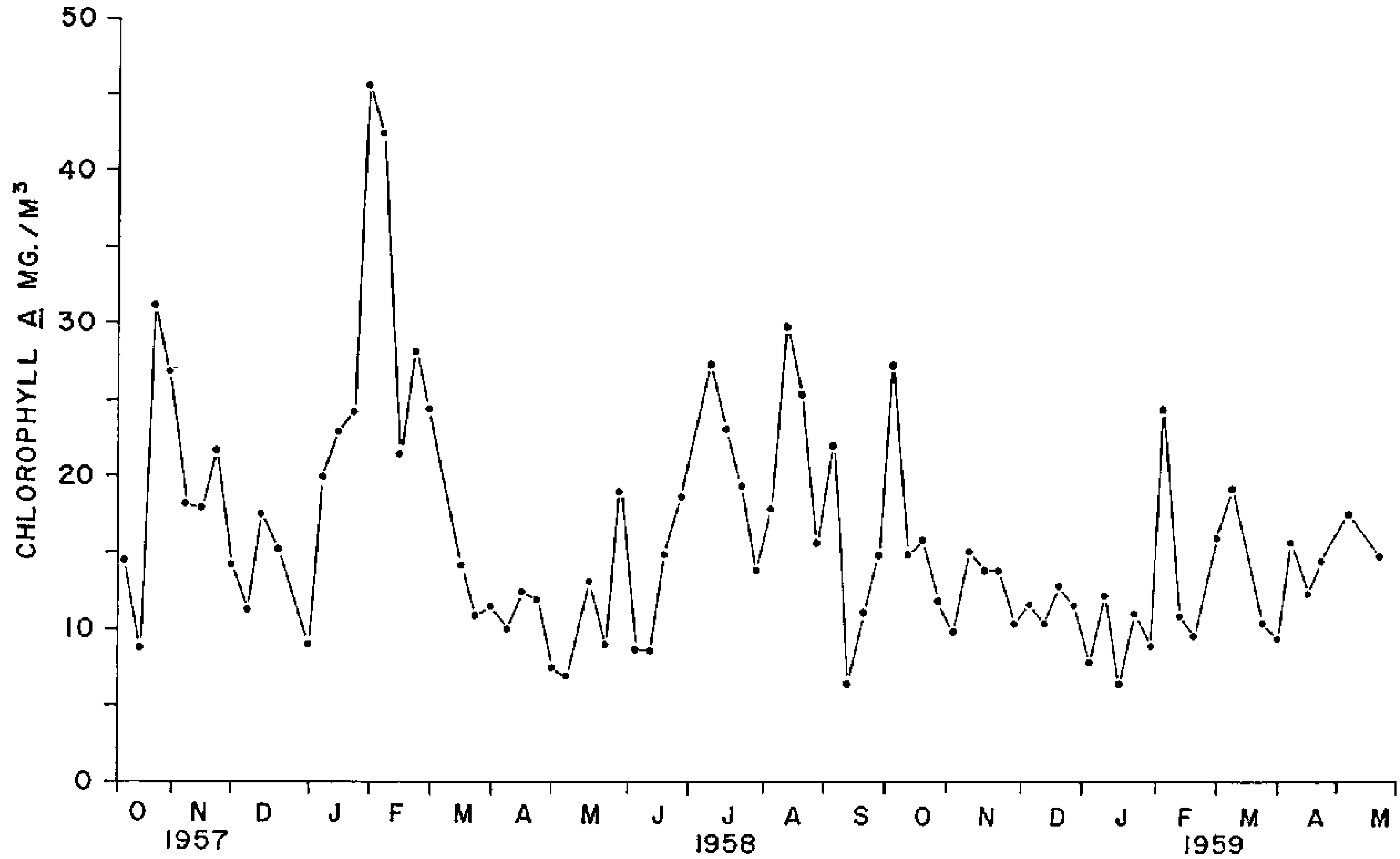

FIGURE 2.—Variation in weekly means of chlorophyll *a* measurements

diation, air temperature, salinity, and rainfall. The values for all data are expressed as the daily mean of all stations for a weekly period (other than rainfall which is expressed as total rainfall per week). The solar radiation data were calculated by the method of Fritz and MacDonald (1949) using the data of the Galveston Weather Bureau for percentage of possible sunshine per day. The air temperatures are means of the daily Weather Bureau observations. Salinity and pigment quantities are means only of the days and times at which samples were taken.

Figure 2 presents mean daily cholorphyll *a* concentrations for the eight stations for the entire period of sampling. An early fall maximum occurred in October in both 1957 and 1958, with a maximum mean of 31.2 mg/m^3 in 1957 and 26.8 mg/m^3 in 1958. The spring phytoplankton flowering began early in January of 1958, and reached its peak during the last week of the month when the mean chlorophyll *a* concentration reached the maximum of 45.8 mg/m^3. The highest value recorded during the bloom was 61.1 mg chlorophyll *a*/m^3 at station 1, but values of 50 mg/m^3, or more, were recorded at all stations. The bloom gradually decreased to a spring and early summer minimum in the months of March through June, followed by a gradual increase with periods of oscillation during July and August. This latter period was characterized by patchy euglenoid blooms throughout the lagoon area, and during one of these the highest value of the survey, 84.5 mg/m^3, was recorded at station 1. This was followed by a more general bloom throughout the lagoon, with a mean of 29.8 mg/m^3, but values were never again as high as those recorded during the spring of 1958. Conditions during September 1958 were disturbed by hurricane Ella which flooded the entire lagoon area introducing large amounts of salt and fresh water. This flooding was immediately succeeded by a marked drop in chlorophyll and other pigments to the low for the observation period, but the depression was only temporary. Immediate increase in values indicated a fall bloom which did not reach the proportions of the fall bloom of 1957. This bloom was followed by a prolonged winter period of low concentrations with a minimum in January. The spring maximum of 1959 occurred in early February, approximately 2 weeks later than in 1958, and apparently did not reach the height of the bloom the year before. These data, however, must be interpreted cautiously since there was a period of almost 3 weeks when no samples were taken, and both sampling frequency and

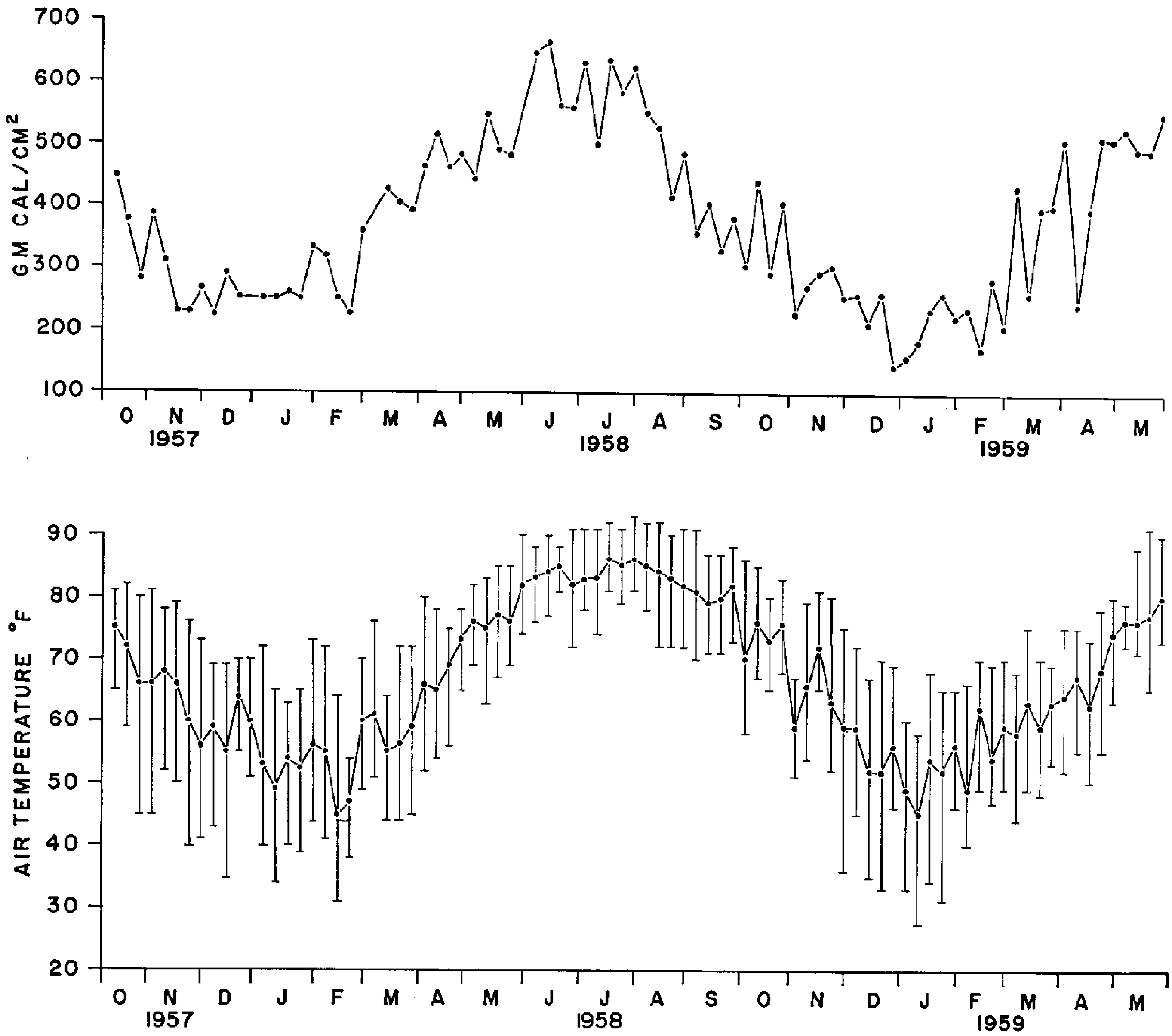

FIGURE 3.—Mean weekly solar radiation and air temperature for the Galveston area. Vertical lines on the temperature graph show the temperature range for each week.

the number of stations sampled had been reduced. The highest value recorded during this period was 26 mg chlorophyll a/m^3 from station 1. Thus, this body of water showed evidence of a cycle in phytoplankton flowering, with peaks in chlorophyll quantity in January or February and again in October–November. The minima occurred in December–January and again in April–May.

The differences in the crops of these years, as shown by the pigment analyses, may be explained in part by the accompanying physical conditions. The solar radiation graph (Figure 3) clearly indicates that there was considerably less light reaching the area during the late fall and winter of 1958 than during the corresponding period of 1957. Similarly, temperatures were lower during the winter of 1958. Since light and heat are two of the requisites for a bloom, the reduction of these may have delayed its onset in the spring of 1959.

Scatter diagrams of solar radiation versus chlorophyll present in the water indicated no relationship that held for the entire period. As has been noted in more northern waters (Smayda, 1957), the autumn and spring flowerings occurred at a time when the radiation curve was changing more or less rapidly. In East Lagoon there was a direct relationship between radiation and chlorophyll *a* for 10 weeks during 1957 (October through December) when the mean daily solar radiation was plotted against the mean daily chlorophyll of the second following week (Figure 4). The relationship would seem to indicate that at the period of declining bloom, light itself may have been the factor limiting the bloom. At

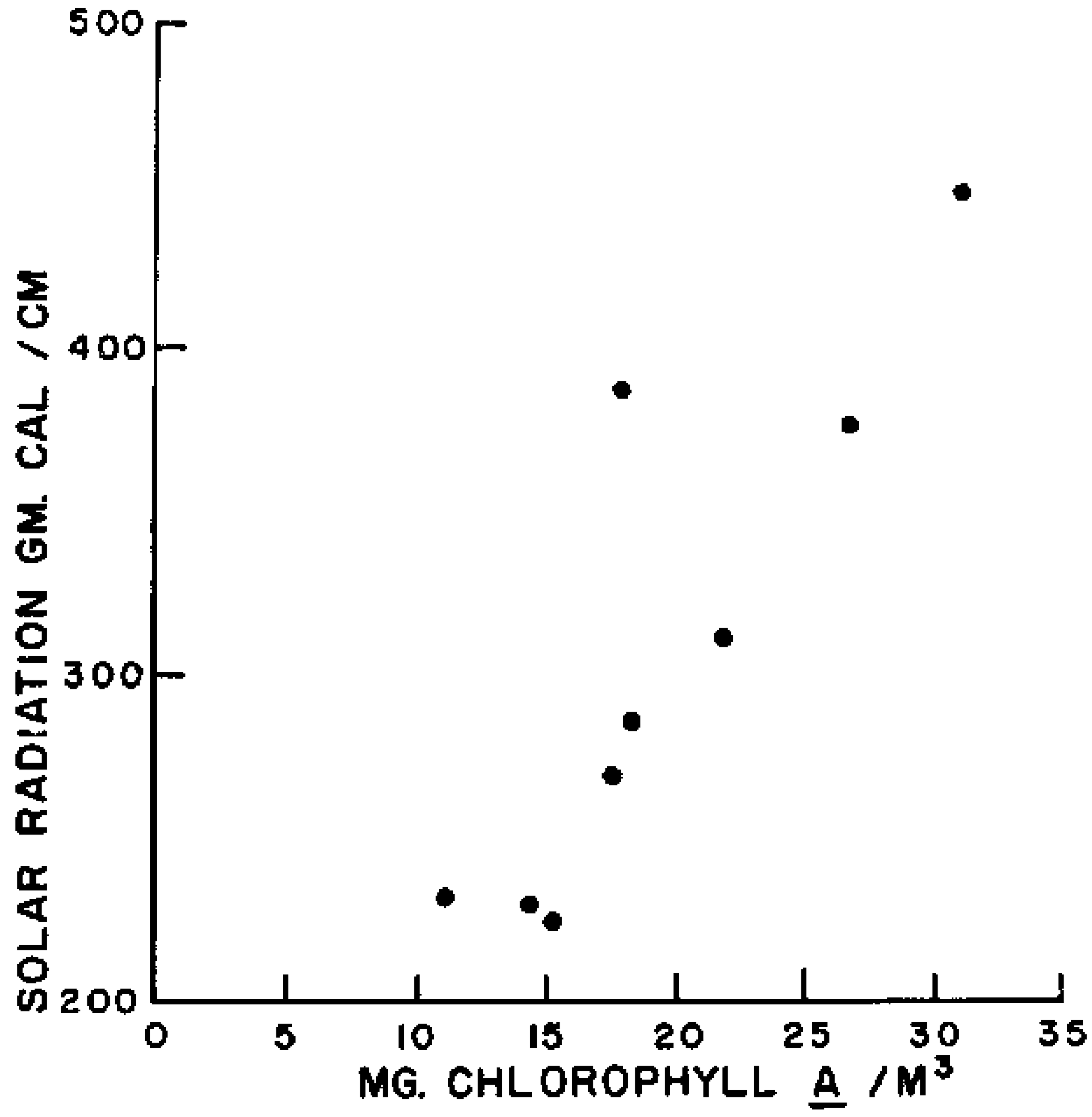

FIGURE 4.—Relation of mean solar radiation and mean chlorophyll *a*, October through December 1957.

no other period during the survey could any relationship be found. Several factors might have been responsible for the lack of correlation in the fall of 1958. They were hurricane Ella, which occurred early in September and flooded the entire area; the presence of the copper ore dike which was placed between stations 3 and 4 during August and October; and the decreased sampling frequency which might have masked the effect of light since the graphs are based on weekly means. In any case, during other periods of the survey other factors apparently had more influence on the growth of phytoplankton than solar radiation.

RELATIONSHIPS OF THE PIGMENTS TO ONE ANOTHER

Generally it may be stated that chlorophyll *c* rose and fell with the rise and fall in chlorophyll *a* (Figures 2 and 5), with the highest recorded value 34.2 MSPU/m^3 at station 1. In one bloom period chrorophyll *c* tended to drop somewhat later than chlorophyll *a*. Chlorophyll *c*, however, apparently was not destroyed as rapidly in the laboratory as chlorophyll *a* so that its later decline may have been an artifact. The ratio of chlorophyll *c* to chlorophyll *a* was greater than one in only 49 of 962 samples examined. This finding agrees with Currie (1958) who stated that ratios below one were characteristic of inshore waters, while the higher values appeared to be characteristic of offshore waters. These differences in ratio may be indicative of a change in population type, since Strain *et al.* (1943) and others have shown that diatoms and dinoflagellates are relatively rich in chlorophyll *c* whereas this pigment is absent from euglenoids and green algae.

Though fairly large quantities of chlorophyll *b* occur in terrestrial plants, only small quantities occur in many planktonic forms. During these investigations the highest recorded value was only 6.7 mg/m^3 in the fall bloom of 1958 when euglenoids were known to be present. There were only eight samples examined in which the chlorophyll *b* concentration reached 5.0 mg/m^3. Even in these samples, however, the chlorophyll *b* was found to represent less than 20 percent of the chlorophyll *a* value and less than 10 percent of the total chlorophyll present. In most cases chlorophyll *b* was found to be less than 10 percent of the chlorophyll *a* value, as might be expected in populations consisting largely of diatoms, dinoflagellates, and euglenoids (Strain, 1951). Ratios above 10 percent occurred with slightly greater frequency at station 1 than at any other station in the lagoon. This probably indicates a slightly different type of community in this area, which was also the site of the heaviest bloom found in the lagoon and the greatest single chlorophyll concentration reported during the entire survey.

Although the carotenoid pigments tended to increase with the chlorophyll concentrations, this was not always the case (Figure 5). In winter, especially, the chlorophyll concentrations were relatively much higher than the carotenoids. This may indicate that there were changes in both type and physiology of the population since it is known that with decreasing light, plants, and plankton as well, tend to increase in chlorophyll content.

Pigment production has been expressed on an area basis following the work of Gessner (1949) who showed that equal areas on the land and water are capable of producing the same amount of chlorophyll. Using this method it was possible to compare the pigment produced at various stations within the lagoon. As mentioned above, station 1 was the deepest station, with stations 7 and 8 the most shallow. Converting chlorophyll *a* from the amount per cubic meter to the amount per square meter (the quantity of chlorophyll beneath a square meter of illuminated surface

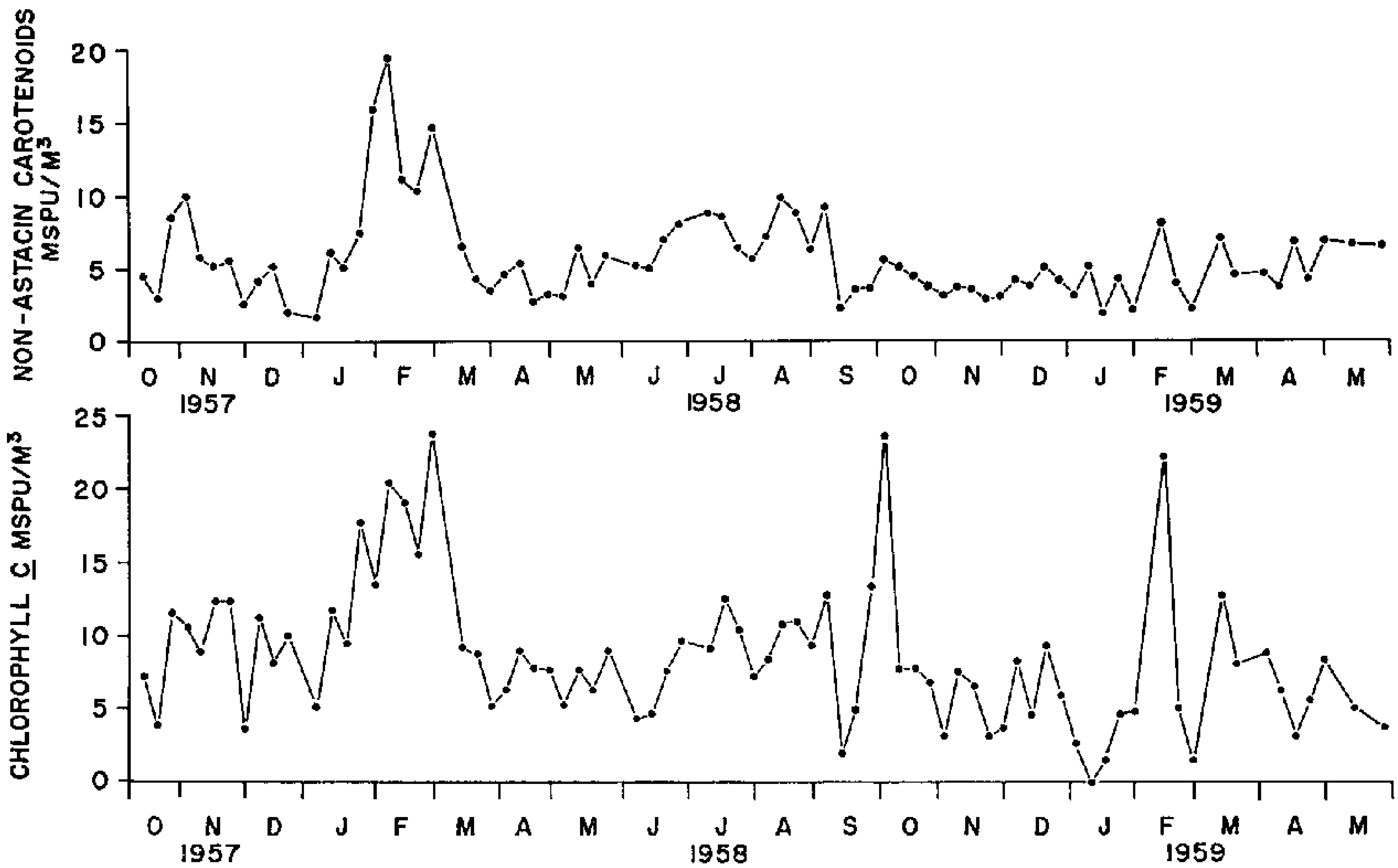

FIGURE 5.—Variation in weekly means of chorophyll c and non-astacin carotenoids.

equals the chlorophyll per cubic meter times the depth of the water column in meters), the same amount of incident radiation yielded more pigment at the head of the lagoon (station 1) than at the mouth (station 7) for most sampling periods (Figure 6). Values at sta-

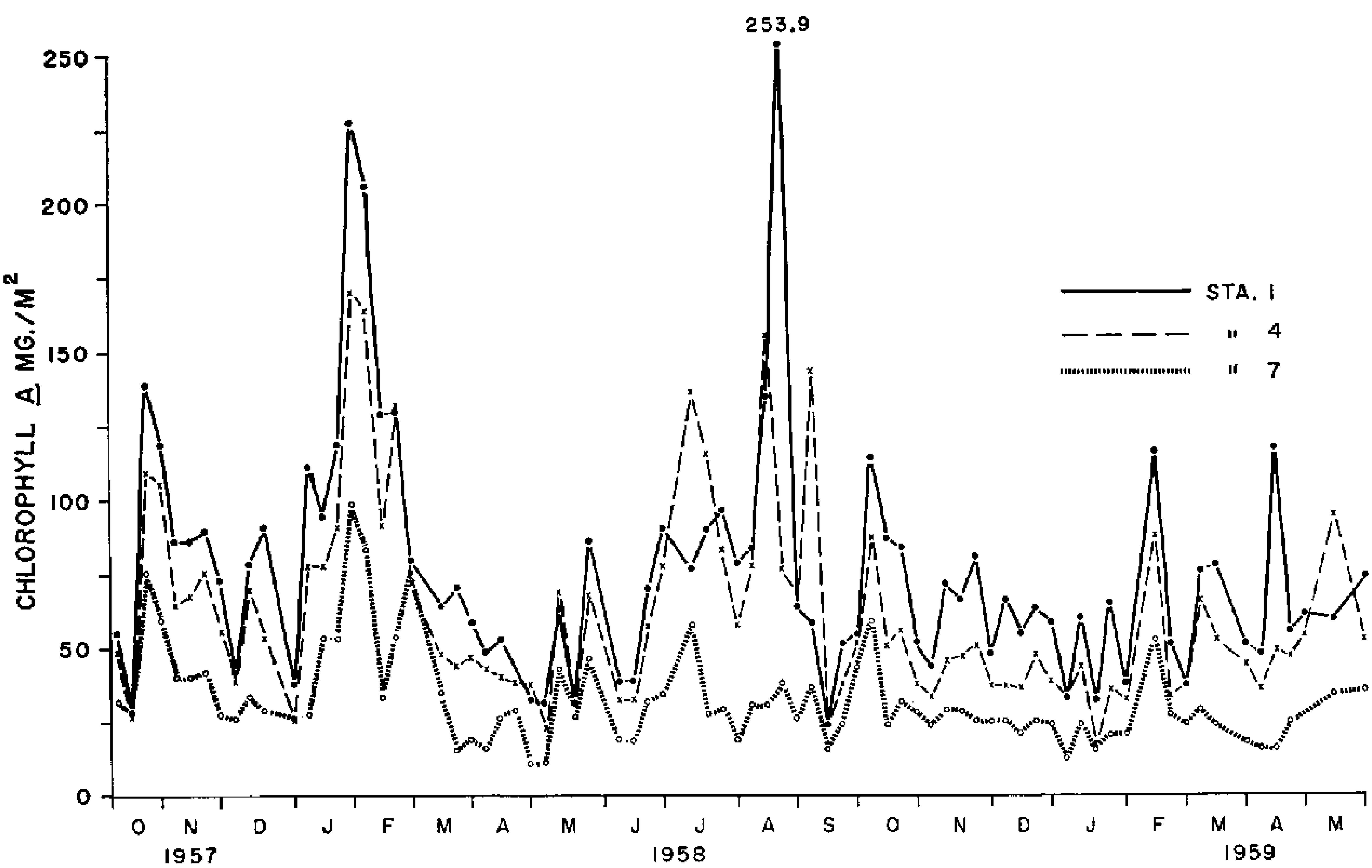

FIGURE 6.—Station variation in chlorophyll a.

TABLE 3.—*Variations among stations for period of observation*

Station	Mean chlorophyll *a* (mg/m³)	Standard error of mean	Range (mg/m³)	Mean chlorophyll *a* (gm/m²)
1	18.50	1.0	2.2–84.1	0.08
4	18.95	0.98	5.0–72.2	0.07
7	15.25	0.75	3.0–51.5	0.04

tion 4, in the middle of the lagoon, were intermediate. Table 3 gives the station variations on both volume and area bases.

Although the differences between stations 1 and 4 are not significant on an area basis, those between stations 1 and 7 and between 4 and 7 are highly significant. This is true for chlorophyll *c* as well, but the differences in mean values for the plant carotenoids (non-astacin type) are not significant. These facts together with variations in chlorophyll *b* and *c* previously cited further indicate the dissimilarity in production of the various segments of the lagoon. Although the spring bloom was found in all stations of the lagoon, the late summer bloom (August 1958) was largely limited to the upper segment of the lagoon (stations 1 to 4) in which the highest chlorophyll concentration of the survey was found.

Several factors may have influenced this gradient in production. First, the stations themselves varied in depth so that even at times when the pigment per unit volume of water was similar, the pigment per square meter was almost twice as great at station 1 as at station 7. Second, there was a correlation with change in tide. A comparison of the occurrence of a chlorophyll gradient along the length of the lagoon and the tidal conditions (as recorded at Fort Point, approximately one-half mile from the lagoon proper) showed that gradients were steeper and occurred more often when the tide was changing, and that gradients were weaker and less frequent with standing tides. Station 7 was obviously far more subject to both tidal and current action than the stations nearer the head of the lagoon and was less apt to receive the enrichment from the drainage of the surrounding marsh than station 1. Since it was likely to be more turbid than the other stations due to this tidal action, there may have been an effective decrease in the amount of light reaching the area as well as a dilution due to the influx of poorer Gulf waters. The combination of these factors may explain why this station appeared to be a poorer producer than those along the upper reaches of the lagoon.

There were no data on turbulence, thermal stratification, or nutrient cycles in East Lagoon which would further explain the differences along the length of the lagoon or the periods of bloom. A study of the nutrients in the lagoon was made for a single 24-hour period during July 1958. The inorganic and total phosphorus had values of about 2.5 mg at. /m³. There was some evidence that station 7 had slightly less phosphorus than the upper stations (about 0.1 mg at. /m³ during the period of study). Station 7 also showed less chlorophyll than either stations 1 or 4, with station 1 having not only the greatest amount of chlorophyll but also showing an increase in chlorophyll during the midmorning followed by a decline toward darkness. These samples were taken 1 foot below the surface rather than from the entire water column.

A comparison of the phytoplankton data with zooplankton data collected simultaneously indicated similar differences among stations along the lagoon, although the gradient was apparently reversed. Station 7 was by far the richest in production of zooplankton, with stations 1 and 4 similar to one another but much poorer producers. A small peak of zooplankton abundance was evident in December 1957, following the October and November phytoplankton bloom, but there was no apparent increase immediately following the very large peak in late January and February (Fleminger, 1959). On the contrary, the zooplankton began to increase late in April and May when the phytoplankton (as judged by the pigment concentrations) was on the wane. The zooplankton population, in fact, began to die out during the late summer when the phytoplankton was again reaching periods of bloom. Both declined during the midwinter of 1958–59 and then showed an apparent peak in February of 1959. It has been postulated that grazing plays a large part in the decrease of phytoplankton (Riley, 1946; Riley and Bumpus, 1946), and during the summer months this would be indicated both by large zooplankton populations at the time when phytoplankton was apparently low and by the inverse relationship of phytoplankton and zooplankton along the length of the lagoon.

Physical factors may also influence the genesis of the blooms noted above. Solar radiation itself did not appear to have a direct correlation with pigment production except during one period of observation. There was apparently a more direct relation with rainfall (Figures 2 and 7). Although a period of

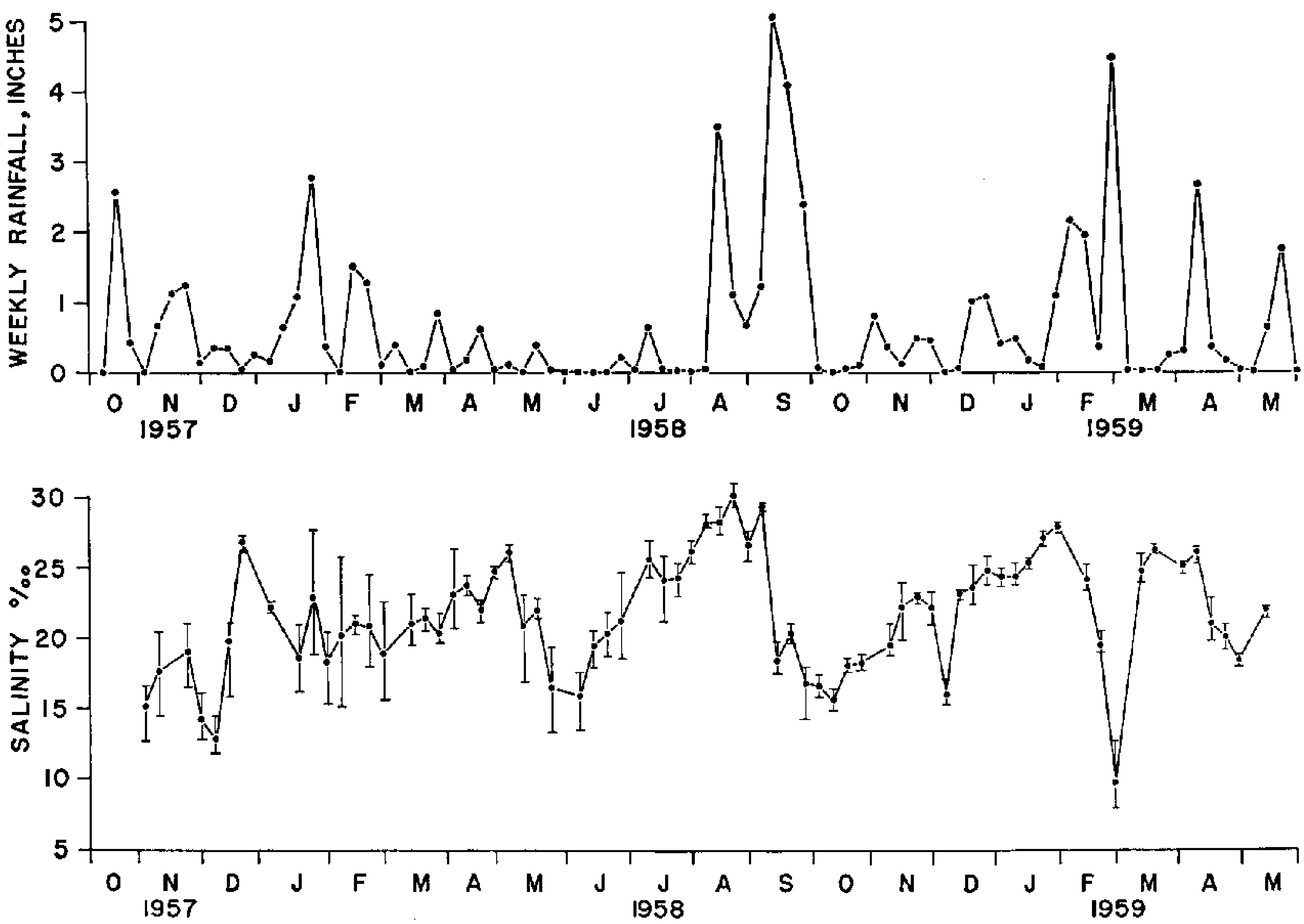

FIGURE 7.—Total rainfall for the Galveston area and mean salinity, East Lagoon.

heavy rainfall alone may not be sufficient to bring about a bloom, rainfall was probably a necessary condition as each bloom was either preceded by (not more than a week) or coincided with periods of relatively heavy rainfall. Further, chlorophyll was minimal during the weeks and months when rainfall was low. The immediate effect of hurricane conditions was a decrease in pigment, due in all probability to the dilution and replacement of the lagoon water by both rain and drainage of the surrounding areas and from the Gulf influx. The hurricane was followed within a week, however, by an increase in pigment concentration. Smayda (1957) has noted the same condition in Rhode Island following the hurricanes of the 1954 season and attributed the immediate appearance of the phytoplankton blooms to an increase in phosphate and iron concentrations. Whether these particular enrichments occurred in the lagoon was not ascertained, but it does seem likely that there was enrichment due to the large influx of drainage water from the surrounding marsh and from the river discharge.

Salinity generally was correlated with rainfall and with season. Values ranged from 8.0 parts per thousand following a heavy winter rain to 31.2 parts per thousand during the late summer. The mean salinity for the entire lagoon for the period of observation was 20.8 parts per thousand.

DISCUSSION

It is necessary to view all results such as these with some caution. When samples are taken several times during the week, conclusions are more firm than when sampling is less frequent. As Rodhe (1958) says concerning the C^{14} method (and it is equally applicable to this type of determination):

> The conclusion that can be drawn . . . is that a sampling frequency as high as once a week need not warrant a true picture of temporal succession. . . . Under such circumstances, we get *one* picture on the basis of samples taken every Monday, but perhaps should achieve quite different peaks and feet in a curve derived from samples taken on Tuesdays, etc. . . . Straight lines connecting weekly dots . . . cannot be regarded, *a priori*, as representative of the course of events during the other six days of the week, neither for the sampling station nor for the lake as a whole. In general, therefore, when

we have to illustrate the seasonal succession, histograms are preferable to smooth or broken curves which easily give the impression of more complete information than the primary results permit.

As mentioned above, the curves given in this paper are averages of all stations for all collections during a given week. Variations in daily means of chlorophyll need not be representative of actual population changes in the lagoon since chlorophyll content changes with the physiological state of the organism, being influenced by nutritional state (lack of essential minerals such as iron), amount of available light, etc. In addition, Rodhe (1958) has demonstrated that chlorophyll content may undergo vast changes from day to day, sometimes of the order of several hundred percent, so that it would be preferable to show actual daily station data. This method would emphasize the fact that frequency of sampling markedly influences the weekly means. Let us compare the two spring blooms, for example. In 1958, samples were taken almost daily so that the weekly average presumably includes the highest chlorophyll values attained during the flowering. In 1959, however, only three stations were being sampled and these at somewhat irregular intervals so that the highest value recorded may not have been the true peak. Since flowerings are notably patchy and occur and diminish with great rapidity, particularly in warmer waters such as those found in the Gulf areas, productivity cannot be accurately quantified unless frequent and regular samples are obtained. Seasonal cycles, however, will be evident.

Seasonal cycles in East Lagoon indicate blooms in January or February and again in October–November with minima in December–January and again in April–May. Atkins and Parke (1951), Atkins and Jenkins (1953), and Jenkins (1955) have reported cycles based on monthly surface samples from the English Channel with maxima in March or April, followed by a decline to a summer minimum and a secondary maximum in September or October. Riley (1946) and co-workers have described similar cycles in Georges Bank and Long Island Sound. In Long Island Sound (Riley and Conover, 1956; Conover, 1956) there was an annual cycle characterized by a large late-winter flowering, with lower values throughout the spring and summer, small sporadic flowerings in summer and early fall, and minimal populations in late fall and early winter. All three studies show similar cycles although the exact time of appearance of the late-winter bloom is dependent upon the latitude.

Wide ranges in chlorophyll content have been reported. East Lagoon has yielded a maximum chlorophyll *a* of 84.6 mg/m^3 for the entire sampling period, with a mean of 17.6 mg/m^3. Marshall (1956), in studies of Florida coastal waters, reported a maximum of about 14 mg chlorophyll *a*/m^3 in Alligator Harbor and a mean of 4.3 mg/m^3. Both are considerably below the values reported here. Even the value of 30.7 mg/m^3 found by Marshall in the midst of a bloom of *Gymnodinium breve* is considerably below the values determined in the midst of blooms in this study. In the Tortugas, Riley (1938) found a mean of 0.33 mg/m^3 of chlorophyll *a*, but these analyses covered only a 2-week period, from July 18 to August 2, when both from my data and from the data of Marshall (1956) it would appear that chlorophyll concentration may not be at its height. Again, Riley (1939) reporting on the western North Atlantic in May and June of 1939, noted that the tropical waters had a maximum of 2.5 mg chlorophyll/m^3 to the 3.6 mg/m^3 of the more northern waters. In Long Island Sound (Riley and Conover, 1956; Conover, 1956) the mean chlorophyll *a* value was considerably lower than that in the enclosed water of East Lagoon, with a maximal value for the years 1952 through February 1954 of only 30 mg/m^3.

Plankton production data from southern regions are somewhat scarce. Odum, McConnell, and Abbott (1958) have reported chlorophyll per square meter for several plankton communities in Texas. Their work indicates that the Texas bays generally yield from 0.043 to 0.200 g chlorophyll *a*/m^2 with a minimum of 0.002 g/m^2 in the Laguna Madre. East Lagoon has given values ranging from 0.044 to 0.37 g/m^2. The latter value, in the midst of a plankton bloom (euglenoid), compares with bloom values from various more northern regions ranging from 0.10 to 0.6 g/m^2 (Odum, McConnell, and Abbott, 1958). Generally, pigment concentrations in East Lagoon may be considered to be higher than those reported by other workers in more open waters, though the maximal concentrations do not reach those reported by others in the midst of special types of plankton blooms.

Organic productivity in the lagoon may be compared with that found in other environments, following the equation of Ryther and Yentsch (1957):

$$P = \frac{R}{k} \times C \times 3.7$$

where P is productivity in grams carbon per square meter per day, R is a radiation factor found from the graphs of Ryther and Yentsch (1957), k is the extinction coefficient of the water, and C is grams of chlorophyll per cubic meter. Assuming an average radiation of 350 gm cal/cm for the period of observation, an average k of 1.7 (estimated from the average Secchi-disk readings by the method of Poole and Atkins, 1929), and using the mean chlorophyll *a* for the lagoon of 17.6 mg/m^3, there was an average production of 0.27 g carbon/m^2 per day or 0.5 g dry organic matter/m^2 per day. The maximal productivity was 1.74 g C/m^2 per day, or assuming the organic product to be 50 percent carbon, 3.5 g dry organic matter/m^2 per day. These approximations compare with maxima for a single day reported by Ryther (1959) of 2.8 g/m^2 per day in the Sargasso Sea with an annual average of 0.9 g/m^2 per day in Long Island Sound.

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